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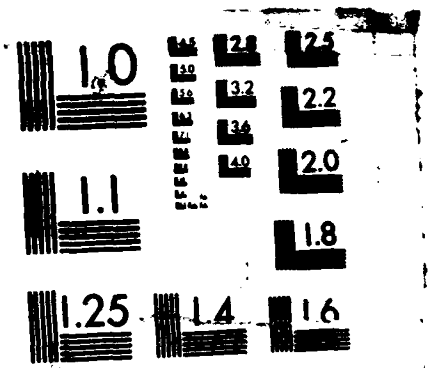


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Full anisotropic behavior of fiber reinforced composites has been studied. Comparison of model predictions with available experiments shows excellent agreement. This also allows the determination of anisotropic fiber properties in an inverse fashion. We have also studied the frequency dependence of phase velocities and attenuation in a particle reinforced composite allowing for the effect of non-perfect interfaces. In addition, calculations have been performed for the dispersion of guided waves in laminated anisotropic plates. In this context effect of interface layers has also been studied.

Simultaneously we have examined ultrasonic scattering by surface-breaking cracks. In particular, we have studied the effect of crack branches on the ultrasonic signal. Scattering of ultrasonic SH waves by buried canted crackes in a thick plate has also been investigated. Here the results of calculations show excellent agreement with available experiments.


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# DYNAMIC BEHAVIOR OF FIBER AND PARTICLE REINFORCED COMPOSITES

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## Summary

Full anisotropic behavior of fiber reinforced composites has been studied. Comparison of model predictions with available experiments shows excellent agreement. This also allows the determination of anisotropic fiber properties in an inverse fashion. We have also studied the frequency dependence of phase velocities and attenuation in a particle reinforced composite allowing for the effect of non-perfect interfaces. In addition, calculations have been performed for the dispersion of guided waves in laminated anisotropic plates. In this context effect of interface layers has also been studied.

Simultaneously we have examined ultrasonic scattering by surface-breaking cracks. In particular, we have studied the effect of crack branches on the ultrasonic signal. Scattering of ultrasonic SH waves by buried canted crackes in a thick plate has also been investigated. Here the results of calculations show excellent agreement with available experiments.

## 1. Ultrasonic determination of mechanical properties of Fiber-reinforced composites

A model has been developed that describes the full anisotropic behavior of uniaxial fiber reinforced composites. Model calculations have been performed for various systems: graphite-epoxy, graphite-aluminum, graphite-magnesium, etc. These results agree well with experiments conducted at the NBS laboratories in Boulder by Dr. H. M. Ledbetter. Theoretical predictions have been used in conjunction with experimental results to inversely calculate graphite fiber elastic properties. This is very useful because not all the elastic constants of graphite fibers are available from the manufacturers. Usually only the Young's modulus information is given. Results of our investigation are reported in [1-3].

## 2. Dispersion of elastic waves in a particle-reinforced composite

Using a scattering approach we have studied [3-5] the frequency dependence of phase velocities and attenuation in a particle reinforced composite. Effects of thin interface layers between the particles and the matrix have been examined. It is shown that the presence of a thin interface layer through which the elastic properties change continuously from those of the particles to those of the matrix usually decreases both the phase velocities and attenuation of plane longitudinal and shear waves.

## 3. Guided waves in laminated composite plates

Guided waves in a fiber-reinforced laminated plate are of considerable interest for analyzing its dynamic behavior and for ultrasonic characterization of defects in the plate. This problem is a rather difficult one to analyze by exact analytical techniques. We have developed a stiffness method that preserves the continuity of displacements and tractions at the interfaces between adjacent layers. This method is quite versatile and applies to wave propagation in any direction in the plane of the plate. The technique has been used to study dispersion of guided waves in a laminated isotropic plate with thin interface layers [3.8] as well as in $0^\circ/90^\circ/0^\circ$ graphite fiber-reinforced epoxy and magnesium plates with or without interface
layers [6,7]. It is found that the presence of low-velocity <interface layers decreases signficantly the phase velocity as well as the cut-off frequency. This phenomenon can be used to characterize interface layers.

## 4. Scattering of elastic waves by buried and surface-breaking cracks

This effort is concerned with ultrasonic scattering by cracks in homogeneous and laminated plates. During the past year we have studied [9] diffraction of SH waves by buried canted cracks in a homogeneous plate. Model calculations have been found to agree well with the experiments performed by Mr. R. E. Schramm at the NBS laboratories, Boulder. We have also examined [9-11] scattering of body and surface waves by surface-breaking canted and branched cracks. It is found that cant angle and branches modify ultraonsic signals measurably. This would make it possible to discriminate between these various cracks.

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